

by transient vertical induction in soft iron is small, and of the same value (nearly) for ships of similar construction.

7. The preceding conclusions point to the conditions which should govern the selection of a suitable position for the standard compass with regard to surrounding iron in the ship.

II. "Atmospheric Absorption in the Infra-Red of the Solar Spectrum." By Captain ABNEY, R.E., F.R.S., and Lieut.-Colonel FESTING, R.E. Received March 5, 1883.

Any investigations on the subject of atmospheric absorption are of such importance in the study of meteorology, that we have deemed it advisable to present a preliminary notice of certain results obtained by us, without waiting to present a more detailed account which will be communicated at a future date. From 1874, when one of us commenced photographing the spectrum in the above region, till more than a year ago, the extremely various manners in which the absorptions took place caused considerable perplexity as to their origin, and it was only after we had completed our paper on the absorption of certain liquids,* that a clue to the phenomena was apparently found. Since that time we have carefully watched the spectrum in relation to atmospheric moisture, and we think that more than a year's observations in London, when taken in connexion with a month's work, at an altitude of 8,500 feet on the Riffel, justify the conclusions we now lay before the Society.

A study of the map of the infra-red region of the solar spectrum,† and more especially a new and much more complete one, which is being prepared for presentation to the Royal Society by one of us, shows that the spectrum in this part is traversed by absorption lines of varying intensity. Besides these linear absorptions, photographs taken on days of different atmospheric conditions, show banded absorptions superposed over them. These latter are step by step absorptions increasing in intensity as they approach the limit of the spectrum at the least refrangible end. In the annexed diagram,‡ fig. 4 shows the general appearance of this region up to λ 10,000 on a fairly dry day: the banded absorption is small, taking place principally between λ 9420 and λ 9800: a trace of absorption is also visible between λ 8330 and λ 9420. On a cold day, with a north-easterly

* "The Influence of the Atomic Groupings of the Molecules of Organic Bodies on their Absorption in the Infra-Red Region of the Spectrum." "Phil. Trans.," Part III, 1881.

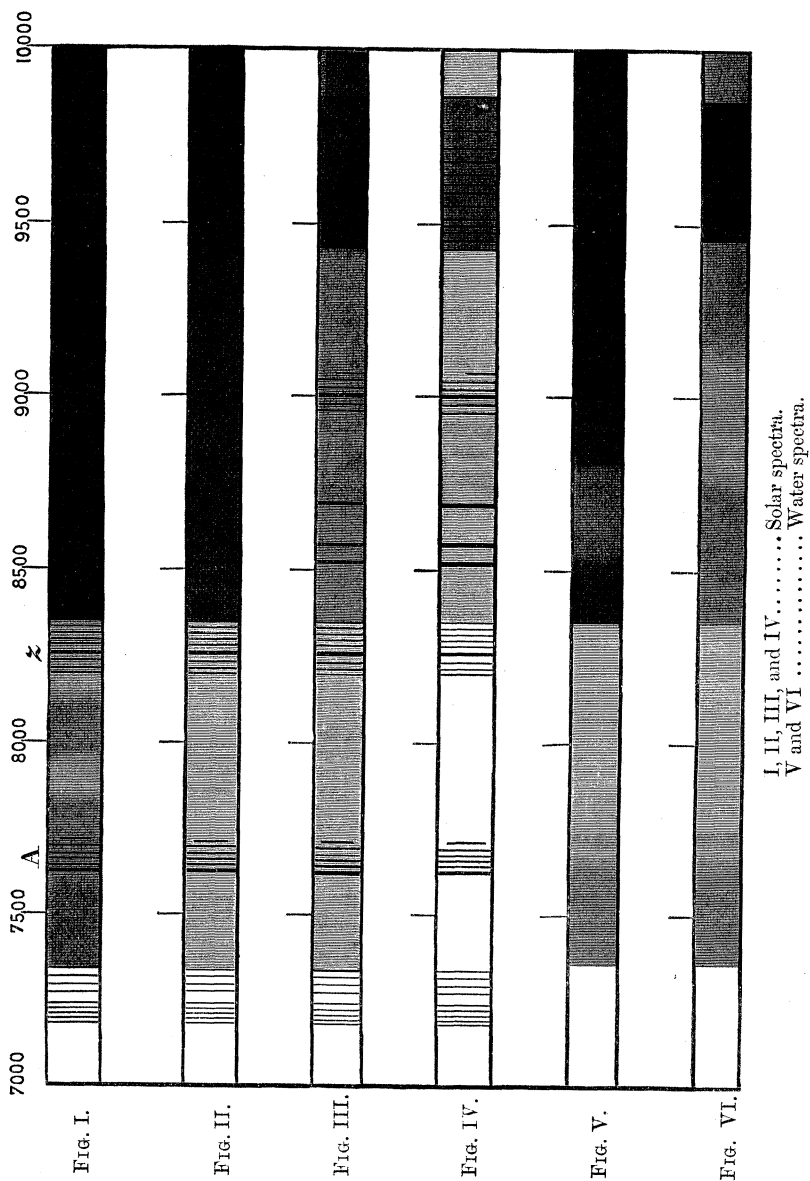
† "Phil. Trans.," 1880.

‡ The lines shown in the diagram are merely reference lines, and have nothing to do with the absorptions under consideration.

wind blowing, and also at a high altitude on a dry day, these absorptions nearly if not quite disappear. If we examine photographs taken when the air is nearly saturated with moisture (in some form or another) we have a spectrum like fig. 1. Except with very prolonged exposure no trace of a spectrum below λ 8330 can be photographed. Fig. 2 shows the absorption bands, where there is a difference of about 3° between the wet and dry bulb, the latter standing at about 50° . It will be noticed that the spectrum extends to the limit of about λ 9420, when total absorption steps in and blocks out the rest of the spectrum. Fig. 3 shows the spectrum where the difference between the wet and the dry bulb is about 6° . Figs. 5 and 6 show the absorption of thicknesses of 1 foot and 3 inches of water respectively, where the source of light gives a continuous spectrum; $\frac{1}{8}$ inch water merely shows the absorption bands below 9420. It will be seen that there is an accurate coincidence between these "water bands" and the absorption bands seen in the solar spectrum, and hence we cannot but assume that there is a connexion one with the other. In fact, on a dry day it is only necessary to place varying thicknesses of water before the slit of the spectroscopic and to photograph the solar spectrum through them, in order to reproduce the phenomena observed on days in which there is more or less moisture present in the atmosphere. It is quite easy to deduce the moisture present in atmosphere at certain temperatures by a study of the photographs. There does appear a difference, however, in the intensity of the banded absorptions in hot weather and in cold about up to 50° . In the former they are less marked when the degree of saturation and the length of atmosphere traversed are the same as in the latter.

The accepted view, we believe, of absorption of vapours is that they give linear absorptions in certain thicknesses, and as the thickness increases or the density becomes greater, the lines blacken, new lines appear, and gradually total absorption sets in in the region where the lines are most numerous and close. It is in the range of possibility that the presence of a small quantity of vapour might show itself as a haze over some region of the spectrum; if, however, the quantity was gradually increased the haze would give place to the lines, and the phenomena just described would be repeated. Suppose several localities of absorption to exist, the absorptive power of the vapour increasing the further the locality was situated down in the infra-red, it might happen that whilst one locality showed only a haze of absorption, one further down might show total absorption, some locality between these two should show linear absorption.

In the case of the absorptions in the solar spectrum we find a very different state of things existing. A comparison of the photographs taken in London on days of different dryness, and with those taken at



the Riffel, shows that the linear absorptions are not increased in number or intensity; except so far that the blackness of the lines is increased by the blackness of the banded absorptions, and the same blackness can be induced by placing a certain thickness of water

before the slit of the spectroscope: another point is that the Fraunhofer lines in certain regions (say λ 9420 to λ 9800) are so irregularly distributed as to preclude the idea that they all belong to the absorption of aqueous vapour, yet all are equally darkened by the band, and they do not spread out as the darkness of the band increases. This is against the view of the bands being formed by aqueous vapour, as we know it.

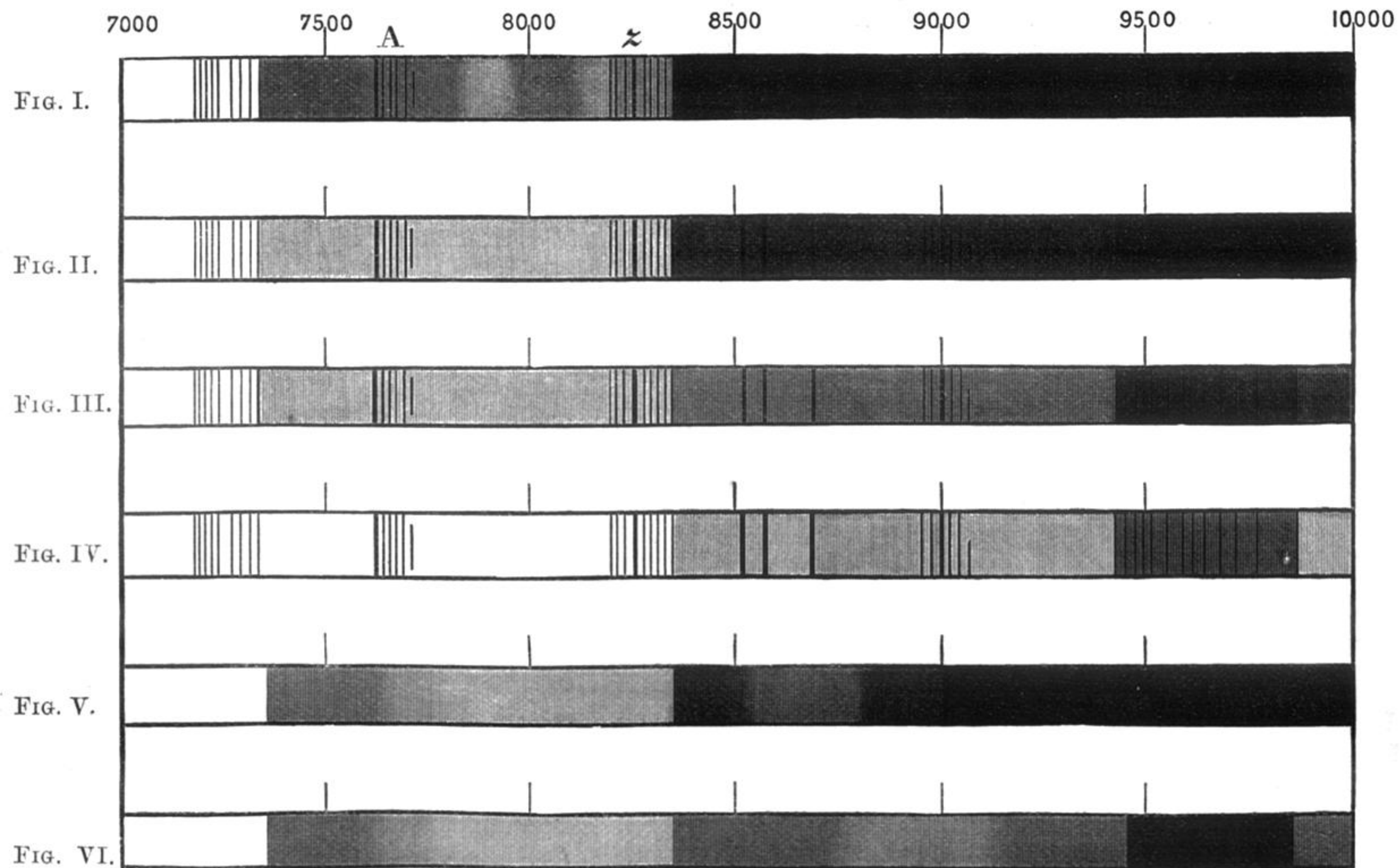
The question then arises as to what these "water bands" can be due—if not due to vapour. This we consider an open question, and one which should be discussed. All we can state is that the absorptions shown are similar to those of water (liquid) and they do not seem to point to the watery stuff existing as vapour,* if we take the visible spectrum as a guide. An intense blue sky at sea-level is often indicative of moisture in the atmosphere, and it also seems to be indicative of finely suspended matter of some kind. If this be the case, can this suspended matter be suspended water stuff? for if it be not, there is no reason why the sky should be bluer on a moist day than on a dry day. We would remark that the deep blue sky at sea-level is of a different colour to the black-blue of high altitudes where, if they exist, the fine suspended particles would be largely diminished in number, and the coarser particles which cause white haze would also be fewer. The great difference of the intensities of the light from the blue sky in England and at 10,000 feet was determined by one of us and communicated to the British Association at Southampton, and the enormous disparity between the two has some bearing on the question we have been discussing.

Addendum.

In the above paper we have described the absorption due to "water stuff" in the atmosphere to λ 9800, as it is only to that wave-length to which the normal spectrum has been as yet published. We wish, however, to add that there are bands commencing at λ 9800, λ 12200, and λ 15200,† giving step by step absorption from the one wave-length to the next, as in the diagram, which also correspond with *cold* water bands. The absorption in the locality from 12200 downwards is usually total, and it is only on dry cold days or at high altitudes that we have noticed that rays of sufficient amplitude can penetrate to cause photographic impression to be made.—March 24, 1883.

* Unless it be held that the water itself holds vapour in solution.—March 12.

† These wave-lengths have been taken from the map of the prismatic spectrum illustrating the Bakerian Lecture, 1880, and are approximate numbers only.



I, II, III, and IV..... Solar spectra.
 V and VI Water spectra.